STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

FINAL REPORT ON

TESTING OF TRAFFIC COUNTING DEVICES

July 1962

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Materials and Research Department

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Mr. George M. Webb
Traffic Engineer
Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

FINAL REPORT ON

TESTING OF TRAFFIC COUNTING DEVICES

Study made by . . . . Structural Materials Section
Under general direction of . . . . J. L. Beaton
Work supervised by . . . . J. E. Barton
Report prepared by . . . . M. Wilson and J. Garcia
Field work by . . . . . . M. Wilson, L. Kubel and J. Garcia

Very truly yours,

F. N. Hveem

F. N. Hveem
Materials and Research Engineer

MW/JG:mw
cc: LRGillis

I. INTRODUCTION

This report is the final report of the traffic counting devices program which was initiated by letter dated September 16, 1960, from G. M. Webb to F. N. Hveem and approved by Mr. J. C. Womack on September 27, 1960.

The primary objective of the test was stated as the testing of four new traffic count devices. These were the Fischer-Porter Traffic Counter, the Kemco Detector, the Tapeswitch Detector, and the Traffonics Multi-Lane Detector.

The following is quoted from the letter of September 16, 1960: "It is requested that you obtain and test these devices under various traffic flow and weather conditions and make recommendations on their possible use in our new mechanized statewide traffic count program scheduled to begin January 1, 1961. It is suggested that these detectors be tested both on the surface of the pavement and embedded in a shallow trench".

These devices and the Honeywell Trafitrol Detector were discussed in the progress report of March 1961. This report will summarize that progress report data and provide evaluation for six new devices in the following order:

A. Fischer-Porter Traffic Counter-Recorder

B. Tapeswitch Detectors (embedded)

C. Tapeswitch Detectors (surface)

D. Traffonics Multi-Lane Detectors

E. Honeywell Trafitrol Infra-Red Detector

F. Aro Sonac Ultrasonic Detector

G. Kemco A.C. Detector

H. Kemco Transistorized Detector

I. Automatic Signal Division RC-1 Radar Vehicle Detector

J. RCA Ve-Det Vehicle Detector

K. Link SLP-3 Presence Detector

L. Fischer-Porter Count Summator Model 55CP1010

Important developments during the course of the test were reported verbally to the Traffic Department at the time of the test.

II. CONCLUSIONS

A. The RC-1 Radar Vehicle Detector (Exhibit 1) performed with an error of 0 to +3% maximum deviation for a period of two months. During a two week period at the optimum setting the error was +1%.

B. The RCA Ve-Det Vehicle Detector (Exhibit 2) performed with a counting error of 1% to 3% high for a period of two months.

C. Although the accuracy of the Link Detector (Exhibit 2) compared favorably with the RCA Detector for short periods, the Link displayed temperature sensitivity and adjustment characteristics judged unsatisfactory for traffic counting application.

D. Tests conducted during this program did not uncover a surface detector superior to the standard road tube. However, the butyl flat road tubing developed by the Accurate Rubber Co. is showing good durability in District operations.

E. The Tapeswitch embedded detectors were insensitive to small cars and also high speed cars.

F. A suitable epoxy for bonding the Traffonics Detector to the pavement was not demonstrated during the tests.

G. The initial adjustment of the Honeywell Model D101 Infra-Red Detector was difficult because of insufficient information. The detector has proved to be temperature sensitive in field use.

H. The Aro Sonac Ultrasonic Detector (Exhibit 3) can only be used successfully as a traffic counter by utilizing the reflective principle. Unfortunately, it was unsatisfactory when used on reflective path because of insufficient gain and slow response time.

I. The A.C. Kemco Impact Detector (Exhibit 3) counted with an error of ± 3% for short day counts but the accuracy varied by as much as 4% from day to day and required frequent readjustment of the gain control.

J. The transistorized Kemco Impact Detector (Exhibit 4) was inaccurate and difficult to adjust for traffic counting.

K. The Fischer-Porter Summator (Exhibit 4) handled two detectors, on a 20,000 ADT highway, and coincidence tests indicate it should be able to handle heavier traffic densities.

III. TEST PROCEDURE

A. Installation of Detectors at Test Site

1. In October of 1960, a 12 ft. instrumentation trailer was placed at the test site near Canterbury Overcrossing on Highway 40, one mile north of Sacramento (Exhibit 6). Five slots, 1¼" wide, 1" deep by 10' long, were cut in the concrete pavement. These slots were used in the testing of the Kemco Detectors and Tapeswitch Embedded Detectors.

2. One dozen Tapeswitch Surface Detectors of the RB-E and RB-W type were installed. The majority were applied to the pavement with a liberal application of Goodyear Pliobond on the bottom of the switch and 3" industrial tape overlapped on the top. This method proved to be very satisfactory.

3. Over a dozen road tubes were placed across the roadway for use with the Streeter-Amet RC and Jr. Counters and the Fischer-Porter Traffic Counters.

4. Two detectors that operate whenever there was a change of inductance in the loop were tested in 1962. One 4' x 5' loop was placed in each lane and one 4' x 20' loop was placed across both lanes. No. 14 AWG with 2/64" insulation was used on all loops. The two 4' x 5' loops were wired with five turns while the 4' x 20' loop had two turns. The wires were laid in a 1" deep slot cut by a 1/8" wide diamond blade. A pourable Polysulfide compound was used to seal the slot.

5. The loop detector wires were spliced to two wire shielded cables at junction boxes near the shoulder, and these cables were run in buried conduit to the trailer approximately 70 feet away. The leads from the surface detectors were terminated in a junction box mounted on the bridge. Overhead shielded cables from the bridge to the trailer were used in the earlier tests. In the later series of tests the underground cables were utilized. All counters and detectors were tested in the trailer except for the transistorized Kemco Detector and several Streeter-Amet RC and Jr. Counters which were under the bridge.

B. Installation of Radar Antenna

The Radar Antenna was mounted over the outside lane at a height of 15' 4" (Exhibit 1). The antenna was placed over the oil deposits in the prevailing path of traffic. The styrene encased antenna weighs only 6 pounds and was easily mounted to the bridge rail with a section of 2" electrical conduit. The lower edge of the antenna was approximately parallel to the road with the leading edge being tilted about 25^{o} up from horizontal. The work was performed by two men working from the bridge. The 100' coaxial cable was run overhead from the antenna to the instrument trailer.

C. Instrumentation

1. Two Berkeley Electronic Counters, Model 5001, one Model 5010 and one Model 10 were used as our basic standards. Frequent hand counts were taken to confirm the accuracy of the counts. Comparison checks were frequently made between the Electronic Counters in the same lane to cover periods not checked by hand counts.

2. The Fischer and Porter Summator (Exhibit 4) was operated by two Ve-Det Detectors. When the Ve-Det output relay actuated, a 6 volt external circuit was completed through a coil of a DPST relay. A Berkeley Electronic Counter and one channel of the Summator were operated by each actuation of the DPST relay. The Summator output was recorded by electronic counter.

IV. DISCUSSION

A. Fischer-Porter Traffic Counter - Recorder

A Fischer-Porter Traffic Counter-Recorder was the first item obtained for test. The time was not available for a comprehensive test before decisions had to be made to start the census program. Comparison counts were run between a Fischer-Porter Portable and Fischer-Porter A.C. Counter against several Streeter-Amet RC Counters. The results were quite comparable when the road tubes were interchanged during the tests. Speed of the traffic was in the 45-60 MPH range. This original Fischer-Porter Counter has been used during the entire Traffic Counting Devices Testing Program. It has proved to be a durable, well designed piece of equipment.

B. Controflex RB-E Tapeswitch (embedded)

In the early phase of the program, five sections of embedded Controflex RB-E Tapeswitch were installed. These detectors were laid at varying depths in slots and covered with several types of compound. The accuracy of the count was poor even with the switch placed flush with the surface of the road. The pressure per square inch necessary to operate the RB-E (20-24 lbs.) was greater than that applied by most foreign and compact cars. The Controflex Type A switch was tested because its sensitivity was rated at only 40 oz. finger pressure. The pressure per square inch to operate the Type A switch was 5 to 8 lbs. but required the complete exposure of the contact ridge. This ruled out the Type A switch as a road switch because it was not designed to withstand the pounding of traffic.

C. Controflex Type RB Tapeswitch (surface)

The highest vehicle count reached by the Tapeswitch Type RB surface detectors was 294,000 vehicles before they became inoperative due to low resistance or shorting. Six of the ten detectors were destroyed before 367,000 vehicles. One detector adhered to the pavement for almost one million counts but electrically had been intermittent after approximately 250,000 vehicles and had shorted out at 960,000 vehicles.

During this test all detectors were subjected to temperatures ranging from 80° F to several weeks of near freezing weather. Several rainy periods occurred during the test. The manufacturer recommends the Type RB Tapeswitch for moderate temperatures and the Type RB-W for cold weather counting (below 41 degrees Fahrenheit). Therefore, several Tapeswitch Type RB-W Detectors (Exhibit 5) were tested in March 1961 with encouraging results. The maximum vehicle count reached 425,000 before failure. Although the vehicle count was high, several of the switches developed intermittent shorts. Upon examination it was noted that a corner of an overlapping segment of the bottom conductor had penetrated the teflon insulation and was shorting to the top conductor. The manufacturer assured us that this situation was corrected and the endurance of the switch improved.

Samples of the improved switch were installed in January 1962. One switch was applied to the pavement with Pliobond and tape. Another was placed across two lanes with tension clamps. The switch applied with Pliobond had good adhesion but shorted out after 145,000 vehicles. The two lane detector reached 260,000 vehicles before one tension clamp broke and the tape was destroyed.

Observations made from the second day of installation until destruction indicated frequent "hanging up" of the Tapeswitch Type RB-W. Several cars would be missed before the short would clear itself.

Results of the test indicate:

1. The Tapeswitch Type RB fails due to sliding and breaking of the copper conductors under heavy traffic.

2. Moisture leaking through loosened end caps is a problem in wet weather.

3. The Tapeswitch Surface Detectors still do not meet the requirements of durability and accuracy desired.

D. Traffonics Multi-Lane Detectors

Four installations of Traffonics Multi-Lane Detectors were made by representatives of Homer-Long Associates and Traffonics over a period of 18 months. Each installation consisted of two dual-lane sections. The first installation, with a 3 inch pressure sealing tape, was losing counts within ten days and had pulled up by the nineteenth day. Early destruction occurred when rain loosened the tape.

The second dual-lane installation of Traffonics Detectors was secured to the pavement with epoxy compound. The detectors were losing counts within 13 days and had stopped counting in three weeks. During the fourth week after several storms, the two detectors in the slow lane became dislodged from the pavement. The highest total vehicle count reached before leakage resistance became too low was 192,500 vehicles per lane.

When one shorted section was removed from the pavement for examination, the encapsulation was observed to have worn through on the bottom surface exposing the bare wires of the leads. Changes in manufacturing processes were made to improve the encapsulation. The steel electrical contacts were replaced with copper contacts. The manufacturer obtained an epoxy resin that he claimed was superior to that used in the first tests.

The second series of tests was started exactly one year later. The third installation of two dual-lane detectors pulled away from the pavement after 5 days and one rain storm. The fourth installation lasted 3 days after one light shower.

The highest total vehicle count of the four installations was 192,500 vehicles per lane. Although the accuracy at the beginning of the tests was high, none of the detectors remained on the pavement long enough to meet durability and accuracy objectives.

Examination of the embedded Traffonics Detectors on the Golden State Freeway disclosed further difficulties in pavement adherence. One detector had pulled out of the groove during wet weather.

Results of the test indicate:

1. A suitable epoxy or method of bonding the detector to the pavement for permanent installations has not been perfected.

2. Use of the ribbon switch detectors such as the Traffonics and Tapeswitch, which have an output pulse of 7 to 15 milli-seconds, requires changing the time constant of the Streeter-Amet Jr. and RC Counters.

E. Honeywell Model D101 Trafitrol Infra-Red Detectors

Two Honeywell Model D101 Trafitrol Infra-Red Detectors were tested. One unit was borrowed from the City of Sacramento and the other from the Bridge Department.

Both units were inoperative when received. Investigation revealed that the "factory adjusted" gain potentiometer in both units had to be readjusted. No adjustment procedure was outlined in the Instruction Manual. The Bridge Department's unit was adjusted by trial and error. This was found to be a long and tedious process as the adjustment was highly critical and the circuit had to be given time to return to a balanced state before the next adjustment could be tried. The second unit was adjusted by setting the units equal distance from identical reflecting surfaces and comparing the lamp voltages of the two units when in a balanced state.

Once adjusted, the devices counted (for short periods) all cars passing under their beams at slow speeds. The City unit was then installed at Canterbury Overcrossing where its vehicle count was checked against an axle count device and found to compare within ± 5%. Under a simulated stable maximum reflecting surface change (simulated rainfall), the units recovered and began counting again after about 20 seconds time lapse.

A more drastic change, such as changing to the reflectance from a car parked under the unit long enough to balance to the new reflectivity base then back to the pavement, might result in a recovery time of 20 seconds to a couple of minutes. While the unit is recovering, the counting device will "see" a closed circuit.

These two units were not subjected to a temperature test but there was an opportunity to examine a detector installed in District III that ceased operating when ambient temperatures exceeded 100° F. The unit was returned to the Maintenance Shop and when case temperatures were normal the unit was operative again.

Results of the test indicate:

1. More information on the gain adjustment would be desirable if practical use is to be made of this detector.

2. Experience of District III indicates that the temperature rating of +120° F. would be easily exceeded during the summer heat resulting in thermal runaway of the Germanium Transistors.

F. Aro Sonac Ultrasonic Detector

An inexpensive ultrasonic type of detector manufactured by Aro Manufacturing Company was also tested (see Exhibit 6). The first tests were conducted at a side-fire distance of 25' from the sensors to the vehicle. This distance approximated two lane coverage with an 8' shoulder. Difficulty was experienced in aligning the sensors at the correct angle for the best reflective path. At this distance the gain control adjustment was too critical.

The next tests were 12' to 15' from the sensors to the vehicle. The gain control was not as critical with the shorter reflective path. However, the transistor amplifier showed itself to be sensitive to high temperature, requiring constant readjustment of the gain control, during two successive days when temperatures reached 108°. In addition, the over-all response time of the circuit was determined to be in excess of 140 milliseconds. At high speeds the time required for small vehicles to pass the sensors would decrease below the response time of the circuit. Tests were not made above 30 mph because of the inability of the unit to count small cars at 30 mph and 12' away.

Results of the test indicate:

1. That the preliminary data indicated no further tests were warranted on the Sonac detector.

G. Kemco A.C. Impact Detector

The Kemco Impact Detector used in traffic signal applications was tested as a traffic counting device. The adjustment of the gain control was critical on picking up truck duals and small cars. A high speed Potter Brumfield SM5LS relay was substituted for the standard relay in an attempt to pick up truck duals.

The counting error varied in the $\pm$ 3% area over short periods during the day. Since we did not conduct 24 hour hand counts, the extra sensitivity due to temperature extremes was not observed. The Bureau of Public Roads had reported that extreme changes in temperature were possibly creating a vacuum in the embedded tubing. Due to this condition the accuracy decreased during the evening and early morning hours.

H. Kemco Transistorized Impact Detector

The Traffic Department was primarily interested in the impact detector for counting in "snow locations". Four Kemco Detectors Model C-600 dual-lane battery powered detectors were installed at three high altitude locations.

The detectors were mounted flush with the shoulder at the edge of the pavement. One detector was used per lane with the outputs brought into a junction box mounted off of the shoulder.

At the Canterbury test site several pourable compounds that had short pot life and a fast cure time were used. Hardness readings with the Shore A_2 Durometer indicated the hardness of these compounds averaged 18 compared to 30 on the standard Kemco compound. The prototype transistorized Kemco detector was tested on two of these pourable compounds with a counting error of approximately -5%. The manufacturer did not rule out the use of a pourable compound with his detector at this time. We were cautioned, however, that the capacitance of the RC circuit would have to be adjusted to operate with the different resistance values of the transducers. On the basis of preliminary tests, one lane at each installation was installed with Ad-Seal 5102 compound, the other lane with the Kemco pourable compound, and no difference in counting ability was noticed. The only difficulty experienced with the Ad-Seal was lack of adhesion at two locations because the primer boiled off when the pavement was overheated. The Ad-Seal Company has since recommended a primer with a higher temperature rating.

Many difficulties were encountered in attempting to make these units operational. Several microphones had to be replaced and some of the "watertight" boxes were leaking (see letter Hveem to Webb, January 19, 1962). Accuracy was around 85% at the best locations.

Following the manufacturer's instructions, these changes were tried at the Canterbury Road installation, using one of their new detectors. A 25' section of counter hose was added between the road and amplifier and an absorbent plug was placed in the end of the detector tube. These adjustments did not help, and it was necessary to change the time constant of the circuit before the accuracy was acceptable. At this time the manufacturer stated it would be necessary to standardize all installations with the same Kemco compound having a similar hardness value, thereby assuring uniformity of air impulses.

It must be stated again that our limited testing did not show any appreciable difference in accuracy between the two compounds at the same installation site. Our oscillograph records did show that from the amount of noise generated in the microphone that it would be impossible to adjust for both truck duals and small cars. The manufacturer reports an accuracy of ½ of 1% for the Model C600 detector during an 8-hour hand count by the Colorado State Highway Department. The manufacturer has offered assistance and material to replace the detection strips, but this has not been done.

I. Automatic Signal Division RC-1 Radar Vehicle Detector

The RC-1 Radar Detector was mounted with relatively little difficulty (see Test Procedure). It was felt that more exacting adjustments would probably have to be made from a ladder truck to obtain optimum performance; however, adjustments to this degree were not deemed necessary as the performance without this fine adjustment was adequate. The antenna was removed and remounted with no difficulty in returning to accurate counts.

The following features are deemed to be undesirable: (a) the distance between antenna and chassis is limited to 100 feet, (b) the coaxial cable is very stiff and difficult to handle. The manufacturer recommends that it should not be kinked, flattened or twisted. (c) The absolute minimum radius which can be tolerated is stated to be 2".

The RC-1 Radar Detector has only the sensitivity control for adjustment. This control is slowly advanced until just one impulse is produced for vehicles and tractor trailer combinations. Different sensitivity settings between 1/3 and 2/3 full scale were tried during a two month period. At approximately the 1/3 setting the counting error is in the ± 1% area. By slightly lowering the setting, the accuracy drops off sharply, but increasing the setting to 2/3 full scale placed the error in the area of 1% to 3% overcount. Observation showed the overcount to be tractor trailer combinations of the type with high trailers.

Results of the test indicate that:

1. The RC-1 Radar Vehicle Detector is a highly accurate vehicle counter.

2. Some difficulty may be experienced in installation of the coaxial cable but the antenna should be trouble free.

J. R.C.A. Ve-Det Vehicle Detector

The R.C.A. Ve-Det Vehicle Detector tests were based on two samples. The counting error over a two month period was 1% to 3% high. Overcounting was observed in tractor trailers, especially those with a long trailer tongue. Comparison tests between the Ve-Det and RC-1 Radar unit showed only a ½% variation over a 6 weeks period. When hand counts were taken, observation showed the variation depended on the type and density of truck-trailer combinations at that particular time of day.

The Ve-Det proved to be simple to tune by the adjustment of three selector switches. During the course of the test at least two dozen set-ups were made by different personnel with no difficulties experienced.

The normal operating temperature range was stated by the manufacturer to be between -22° F and +140° F. A temperature test run at the extremes of the range for two hours confirmed this specification. No drift was noted or detuning of the loop from the oscillator frequency of the sensor unit. During the three month test period the ambient temperature at the test trailer varied from a low of 28° F to a high of 85° F.

Lead lengths to the loops at the test site varied from 65' to 115' from the trailer. The manufacturer of the Ve-Det recommends that the lead-in length should not exceed 150', which is more than adequate for most installations.

All tests on the Ve-Det were run with power supplies which operate on 117 volts A.C. and furnish -24 volts D.C. to the Sensor Unit. The current drain on the Ve-Det is 80 milliamperes. For portable operation a 24 V wet cell would be necessary. The Ve-Det Sensor Unit can be mounted in the Fischer-Porter Traffic Recorder, but the battery would be external. It is therefore recommended that wherever practical 117 V.A.C. power should be provided. One power supply will handle up to four detectors.

To offset the disadvantage of requiring 1 hour per lane cutting time and another ½ hour wiring time on the detector loops, is the fact that once installed correctly the maintenance should be nil.

Results of the test indicate that:

1. The Ve-Det has a satisfactory vehicle counting accuracy.

2. The Ve-Det will meet temperature requirements.

3. No maintenance should be required on the detector loops.

4. The Ve-Det should be operated on 117 V.A.C. wherever feasible.

K. Link SLP-3 Presence Detector

The Link Presence Detector tests were based on three samples that were supplied in succession. The final tests were based on Model SLP-3. Power was supplied by a 12 volt battery; however, power supplies are available.

Considerable interest had been shown in the Link Detector because it was $115 cheaper than the Ve-Det, came in a smaller package, operated with 12 V.D.C. instead of 24 V.D.C. and had the presence detection feature.

The following difficulties were experienced with the Link Detector:

1. Tuning of the loop requires a capacitor decade box to select the correct capacitance. Then when a capacitor of the same value is substituted, further adjustment of the capacity is usually needed to reach the optimum tuning point.

2. The Link proved to be highly sensitive to temperature changes. This shortcoming was first noticed with Model SLP-2X during one week of cold temperatures when the daily temperatures were dropping to 28° F. The output relay would be locked into the closed position each morning. A temperature test confirmed the unit to be inoperative at +20° F. The manufacturer replaced this unit with their latest Model SLP-3 which they stated would eliminate the temperature sensitivity. However, the temperature test showed the range to be +10° F to +140° F compared to their specifications of -40° F to 140° F. The SLP-3 unit required almost daily adjustment of the loop capacitance to maintain counting accuracy of 2-3% overcount.

The current drain of the Link is 40 milliamperes plus the external relay coil current for a total of 130 to 160 milliamperes. This is approximately twice the current drain of the Ve-Det.

The lead length to the Link Detector is also a consideration. Lead length should not exceed 60 feet or approximately one ohm lead resistance.

Results of the test indicate:

1. The Link is too temperature sensitive.

2. The Link is difficult to adjust compared to the Ve-Det.

L. Fischer and Porter Count Summator Model 55CP1010

The Fischer and Porter 55CP1010 Count Summator was designed for use with two to six vehicle detectors. The pulses from the detectors may be in any random sequence or coincidence and the Summator memory is designed to retain the total of vehicle actuations.

Coincidence was induced by jumpering 2 inputs, then 3 input channels into the Summator. Coincidence counts were simulated 10,000 times with only 2 misses. Three simultaneous inputs for 230 actuations produced one miss.

The Summator was tested under normal conditions with two Ve-Det Detectors as described in the test procedure. Out of 118,000 actuations 11 vehicles were missed.

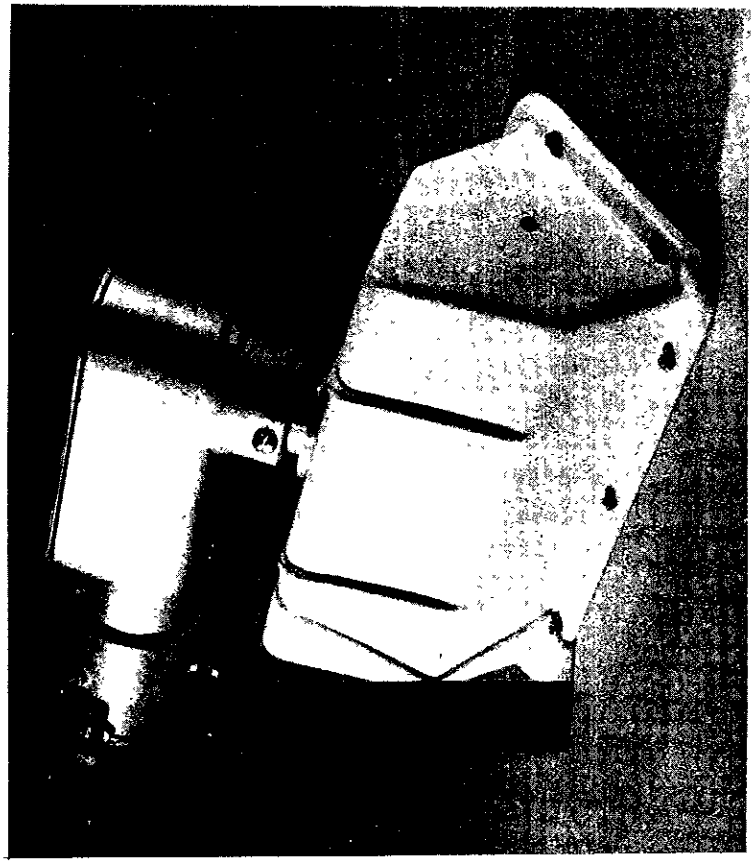
Results of the test:

The Fischer-Porter Summator handled two detectors, on a 20,000 ADT highway, with an 0.01% error. Results of the coincidence tests indicate the Summator should be able to handle the heavier traffic densities.

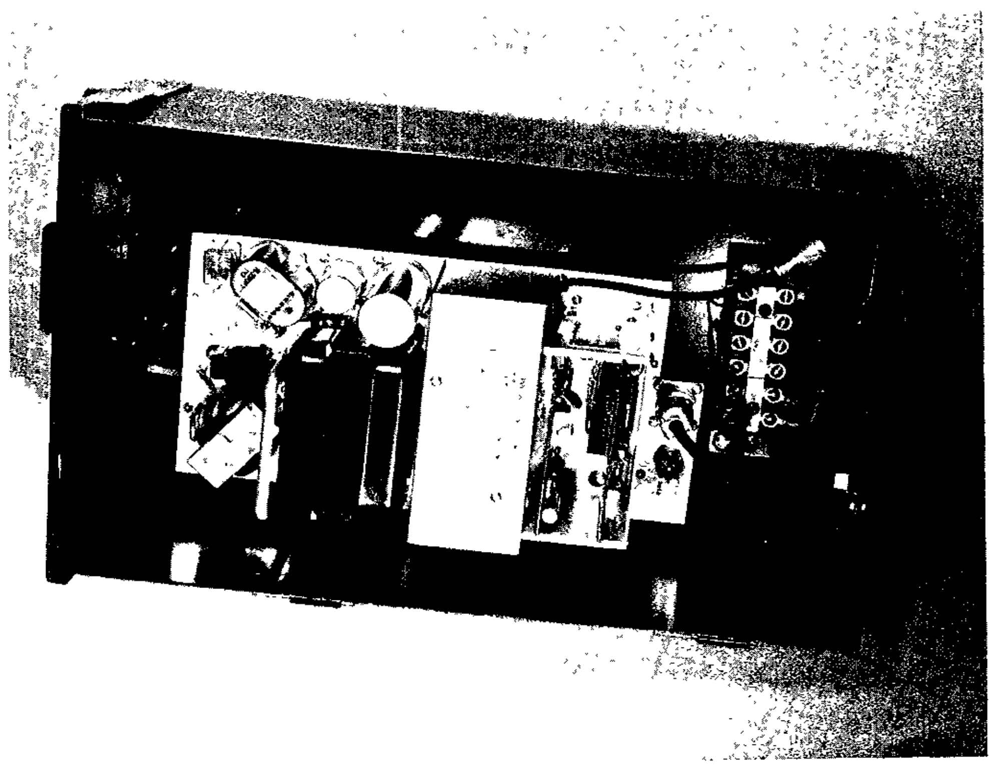
V. APPENDIX

Exhibit 1	Photographs of Automatic Signal Radar Detector Chassis and Antenna
Exhibit 2	Photographs of Ve-Det Detector and the Link Presence Detector
Exhibit 3	Photographs of Aro Sonac Detector and AC Kemco Impact Detector
Exhibit 4	Photograph of the Prototype Transistorized Kemco Impact Detector and the Fischer-Porter Count Summator
Exhibit 5	Photographs of Traffonics Detectors and Tapeswitch Detectors
Exhibit 6	Photographs of Canterbury Road Test Site and Test Equipment in Trailer

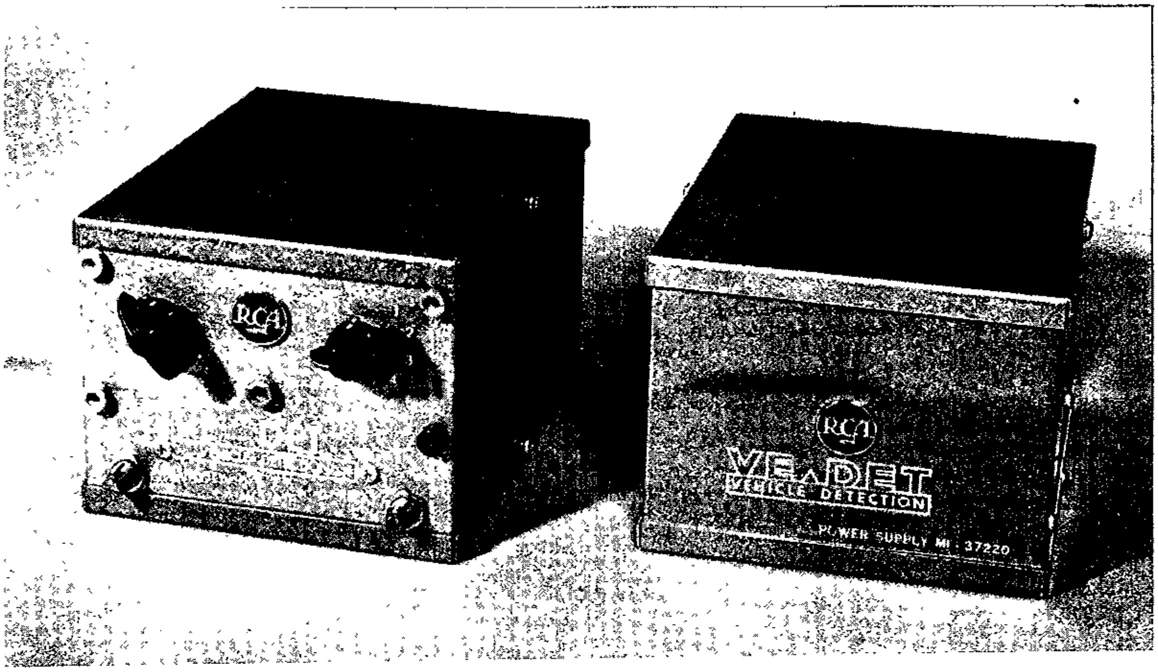
Exhibit 1



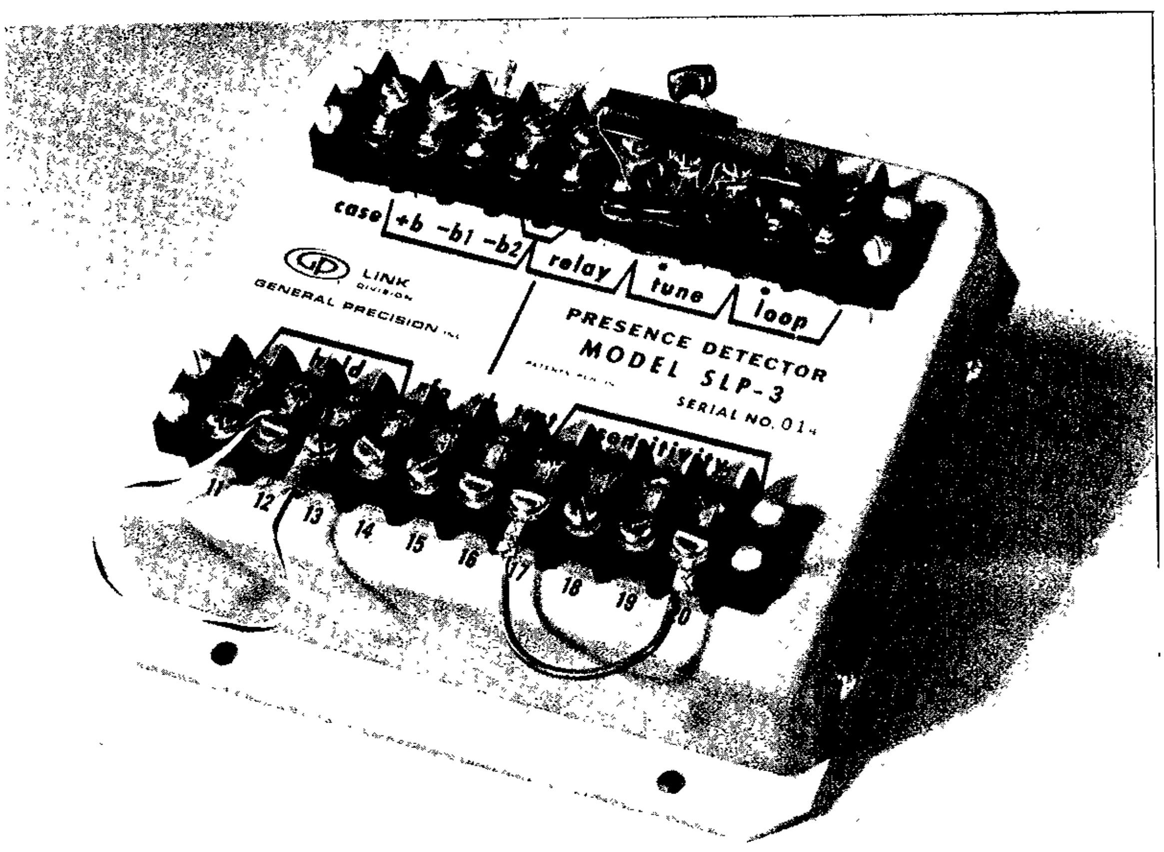
Radar Antenna



Automatic Signal Radar Detector Chassis

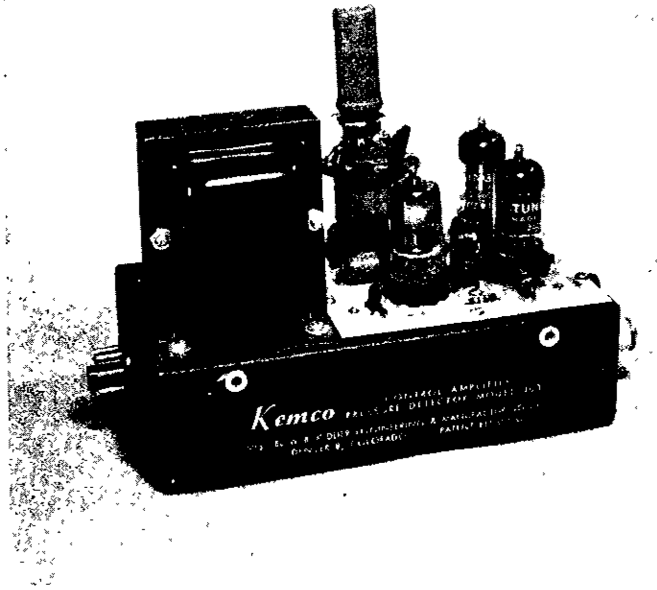


Ve-Det Detector and Power Supply

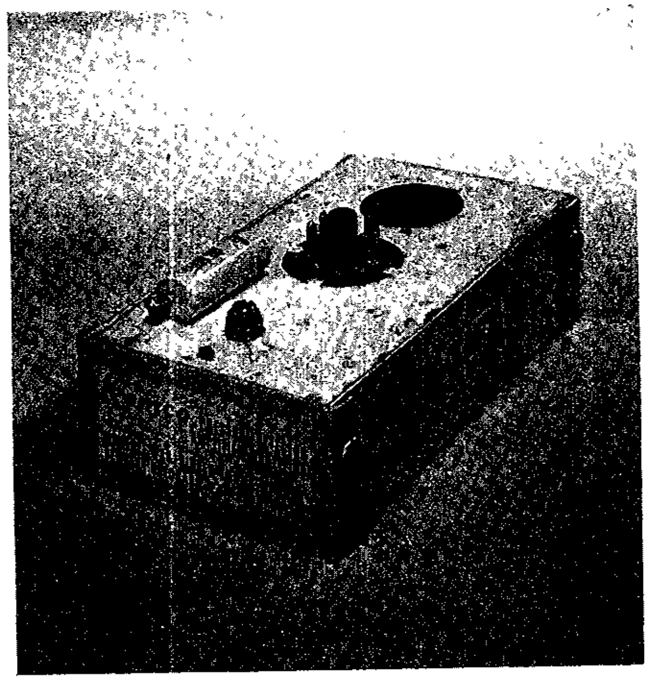


Link Presence Detector

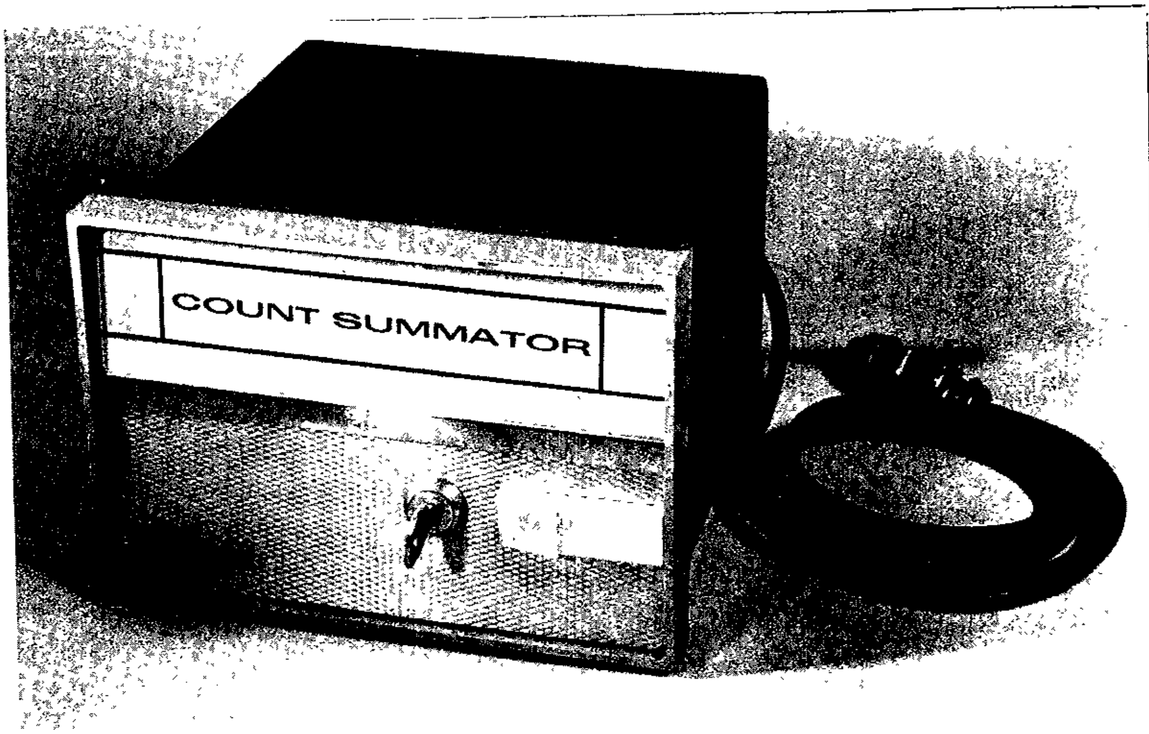
Aro Sonac Ultrasonic Detector



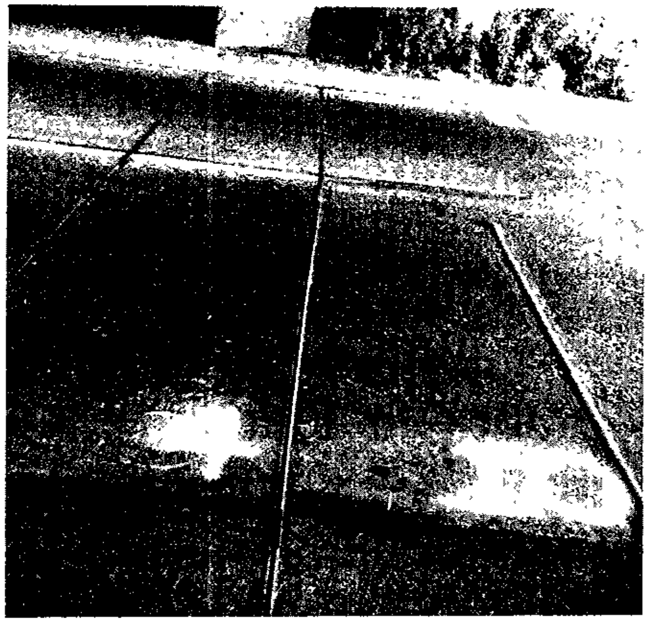
A.C. Kemco Impact Detector



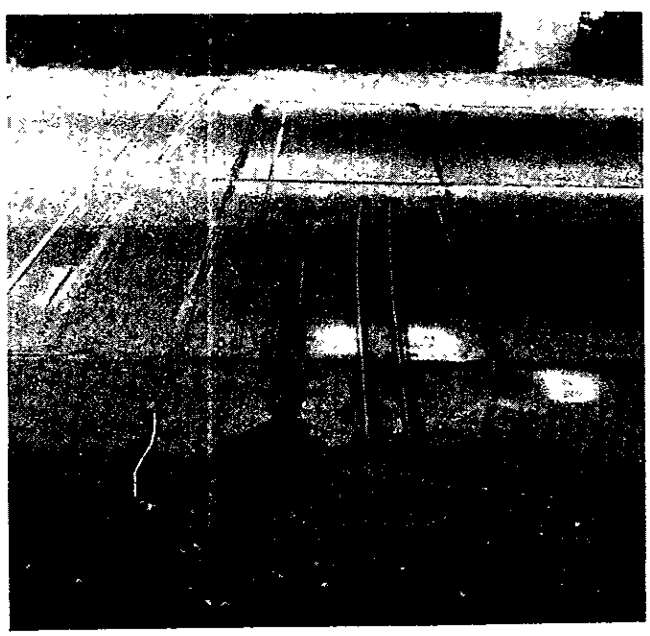
Prototype of Transistorized
Kemco Impact Detector



Fischer-Porter Count Summator

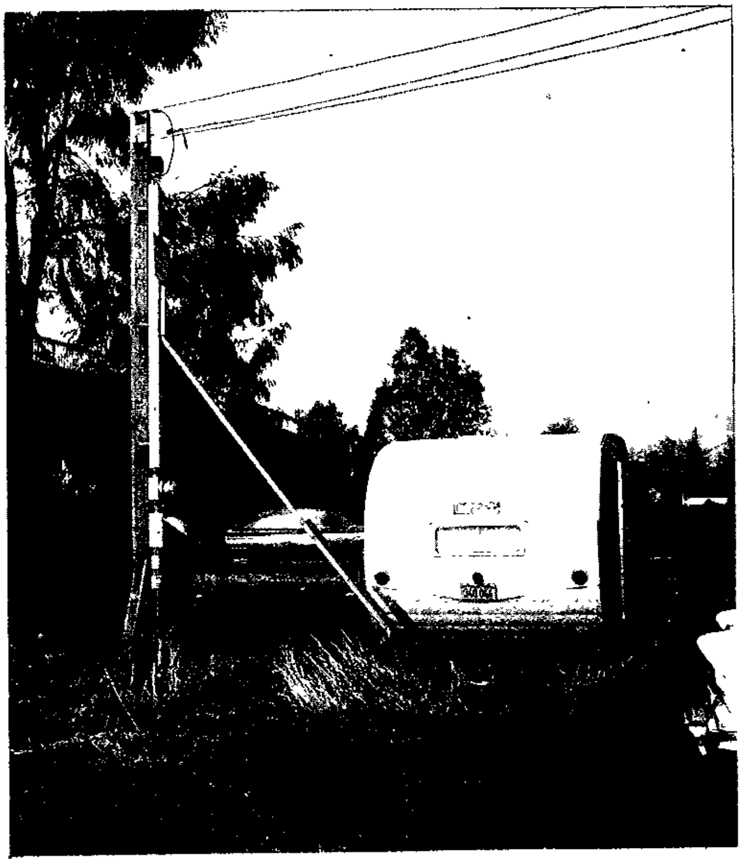


Two Traffonic Detectors on the left.
Tapeswitch #10 on the right.

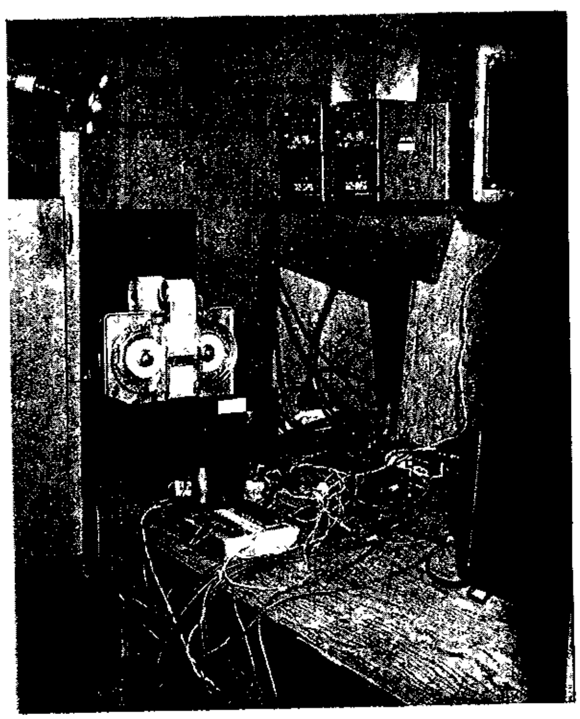


Tapeswitch Detectors Nos. 8, 9, and B

Exhibit 6



Canterbury Road Test Site



Test Equipment in Trailer